Interest Rate Parity and Monetary Integration: A Cointegration Analysis of Sweden and the EMU

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Abstract

This thesis provides a thorough analysis of the covered- and uncovered interest parity conditions (CIP, UIP) as well as the forward rate unbiasedness hypothesis (FRUH) for Sweden and the European Economic and Monetary Union (EMU). By studying data on interbank rates in Sweden (STIBOR) and the EMU (EURIBOR) as well as the corresponding spot- and forward exchange rates, monetary integration and country-specific risks are determined and analyzed with direct applications to the potential entry of Sweden into the EMU. As interest rate parity in general gives insight into market efficiency and frictions between the chosen regions, such points are discussed in addition to EMU entry. Drawing on past studies that mainly studied one condition in isolation, a nested formulation of interest rate parity is instead derived and tested using cointegration and robust estimation methods. The results point to a strict rejection of the FRUH for all horizons except the shortest and a case where CIP only holds for the 6-month horizon and partially over one year. This implies, based on the nested formulation, that UIP is rejected for all horizons as well. Ultimately, the study concludes that a Swedish entry into the EMU is not motivated given the lacklustre results on UIP and due to the lack of monetary integration.

Keywords: Interest Rate Parity (IRP), Covered Interest Parity (CIP), Uncovered Interest Parity (UIP), Forward Rate Unbiasedness Hypothesis (FRUH), Monetary Integration, Sweden, EMU, STIBOR, EURIBOR, Cointegration, Johansen Test, Dynamic OLS
**Sammanfattning**


Nyckelord: ränteparitet, ränteparitetsvillkoret, kurssäkrad ränteparitet, icke-kurssäkrad ränteparitet, effektiva marknadshypotesen, valutaterminer, monetär integration, Sverige, EMU, STIBOR, EURIBOR, kointegration, Johansen test, dynamisk OLS.
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1 Introduction

For countries within the European Economic and Monetary Union (EMU), monetary integration is a key determinant for the success of membership. Being a wide concept, monetary integration includes capital market substitutability, monetary policy integration as well as exchange rate stability. As an initiative to maintain monetary integration between the EMU and Euro-accessing countries, the Exchange Rate Mechanism (ERM) has been a tool of the European Union (EU) to reduce fluctuations in exchange- and interest rates against those countries that will potentially adopt the Euro. Sweden, as a member of the EU, has not yet adopted the Euro but have been close to enter the ERM as the economy is closely related to those within the EMU. This study will take a closer look at some underlying factors that could potentially speak for a re-evaluation of the adoption of the Euro in Sweden. Specifically, the thesis will aim to answer two separate but related questions: 1) “Does the covered- and uncovered interest parity condition hold between Sweden and the EMU?” and 2) “Is there evidence of monetary integration between the two regions that could motivate a Swedish entry into the EMU?” The former question is better off answered using quantitative techniques whereas the latter benefits from a thorough qualitative analysis of earlier studies on monetary integration combined in a discussion with results on interest rate parity.

Because there are conceivable benefits to Sweden in a potential EMU entry, among them reduced transaction costs and increased trade, there is great motivation for re-evaluating membership as it can potentially increase Swedish competitiveness (Flam, 2011). Furthermore, the level of monetary integration is not only a topic of discussion in entering a monetary union, but a broader measure of frictions in capital markets that in itself gives insight into the level of trade. Since trade between countries becomes increasingly more important for country-specific competitiveness, studies on this topic is not only important for policymakers but also for decision makers in businesses. In modeling monetary relationships, the main threat is market volatility and uncertainty which both vary in time and makes any model derivation a complex task. Nevertheless, the importance of such modeling is crucial to policymakers as it provides groundwork for policy as well as guidance for central banks in determining interest rates.

The covered- and uncovered interest parity (CIP, UIP) conditions are both well-studied concepts in macroeconomics and relate the interest rate differential to the exchange rate change between two countries (Feenstra & Taylor, 2008). Specifically, CIP states that the interest rate differential should equal the percentage difference between the forward- and current spot exchange rate. UIP, on the other hand, is a pure expectation based relationship that states that the interest rate
The differential between two countries equals the expected percentage change in the spot exchange rate. The two conditions are both of great importance as they give insight into market imperfections and how risk premiums materialize (Frankel, 1992).

Furthermore, deviations from UIP and evidence of a foreign exchange risk premium are both commonly used in the literature as determinants of capital market substitutability (Holtemöller, 2005). Since capital market substitutability is a measure of monetary integration, UIP can be used as a point of discussion for monetary union as one condition to enter is that financial assets are substitutes between economies (Ferreira, 2011). The potential entry of Sweden into the EMU can, therefore, be evaluated using UIP where the ideal environment would suggest its existence. In addition, CIP is often used to determine the efficiency of financial markets and capital market mobility as it is based on the assumption of no arbitrage in the forward exchange rate market (Frankel, 1991). The two conditions are thus of great importance in the assessment of financial markets as well as in discussions on policy with respect to topics such as potential EMU entry and determination of interest rates.

Both conditions have been studied extensively with mixed results (Ferreira, 2011; Kasman, Kirbas-Kasman, & Turgutlu, 2008; Holtemöller, 2005; Jochem & Herrmann, 2003; Alexius, 2001). UIP is usually rejected whereas CIP has proven to hold more frequently (Ferreira, 2011). The main reason for the rejection of UIP is, as literature suggests, due to the existence of a time-varying risk premium (Meredith & Chinn, 1998). Furthermore, most studies regard the conditions in isolation and only focus on either of the two relationships, a surprising trait of past studies since the rejection or acceptance of one condition enforces constraints on the other with respect to underlying assumptions. This is where the authors follow a slightly different road than the majority of previous studies in the sense that both relationships will be studied, as well as their interdependence, with the specific view of the Swedish entry into the EMU and a contrasting feature relating pre- and post-crisis conditions. Mainly due to the need for assessing both relationships in a discussion on monetary integration between Sweden and the EMU, the conditions will be studied extensively by looking at interest rate differentials in the interbank markets and corresponding exchange rate changes using forward- and spot exchange rates on horizons less than one year. Additionally, the separate link between the two, the forward rate unbiasedness hypothesis (FRUH), is used to tie the two relationships together and to provide a deeper discussion on a potential Swedish EMU entry.


2 Theory

The theory and motivation for many macroeconomic relationships derive from the concept of no arbitrage. For covered- and uncovered interest parity (CIP, UIP) this is especially true. Because the actual existence of interest rate parity can be counter-intuitive, it is easier to depart from the covered perspective using forward exchange rates as an explanation for the phenomena. This is where the start of discussion on the topic takes place. After that, some preliminaries of econometric time series is considered in order to introduce unfamiliar readers to the theory that the later econometric methodology will build upon, where the main concepts will be cointegration, hypothesis testing and regression with non-stationary time series. Lastly, the formal hypothesis of the thesis is presented.

2.1 Interest Rate Parity in a Broader Perspective

Interest rates are fundamentally important in the study of economics as they steer the flow of capital in any given economy in their effect on money demand. Central banks use this fundamental trait to ease out business cycles and stimulate growth by increasing or decreasing benchmark yields (Nessén, Sellin, & Åsberg Sommar, 2011). Thus, the increasingly more important relationship, especially in a globalized world with increasing levels of trade throughout economies, is the effect that interest rates has on the exchange rates between countries.

Covered interest parity (CIP) is the direct application of no arbitrage to the relationship between interest rate differentials and exchange rate changes. It states that the difference between the interest rates available in two countries must equal the expected percentage change in the spot exchange rate with respect to the forward exchange rate available today (Feenstra & Taylor, 2008).

For explanatory purposes, consider a domestic investor with the opportunity to deposit the available capital $M$ in either a domestic or foreign bank account with the respective interest rates, $r_d$ and $r_f$. Additionally, if the investor chooses to invest in the foreign bank account, the capital need to be exchanged at the current spot exchange rate $S_t$\textsuperscript{1} at time $t$ but then need to re-exchange at time $t + m$ and would therefore cover this exposure using the current forward exchange rate $F_t^m$. The two possibilities are summarized in (1) and (2) below:

\begin{align*}
\text{(1)} & \quad S_t \times \frac{1}{F_t^m} \\
\text{(2)} & \quad S_t \frac{1}{F_t^m} \\
\end{align*}

\text{1 The exchange rate will be defined as foreign in terms of domestic throughout this thesis.}
Investing in the domestic bank account: \( M \times (1 + r_D) \)  

(1)

Investing in the foreign bank account: \( M \times \frac{1}{S_t} \times (1 + r_F) \times F_t^m \)  

(2)

Since these are trading opportunities that the investor can do today and bear equivalent risk, by the no arbitrage theorem they must equal each other. In other words, the following must hold:

\[
M \times (1 + r_D) = M \times \frac{1}{S_t} \times (1 + r_F) \times F_t^m
\]

(3)

By rearranging and approximating (3), the more commonly used expression for CIP is obtained:

\[
\text{CIP: } r_D - r_F = \frac{F_t^m - S_t}{S_t}
\]

(4)

Here, \( r_D - r_F \) is the interest rate differential and \( P_{\text{Forward}} = \frac{F_t^m - S_t}{S_t} \) the forward premium\(^2\) or discount on the foreign currency defined as:

\[
P_{\text{Forward}} = \begin{cases} \text{forward premium,} & P_{\text{Forward}} > 0 \\ \text{forward discount,} & P_{\text{Forward}} < 0 \end{cases}
\]

(5)

Instead of using the forward exchange rate today to cover exchange rate exposure, the investor might choose to be uncovered and wait until the end of the investment horizon and use whatever exchange rate that is available at that time. In this case, the investor’s current expectation of the future spot exchange rate will be of fundamental importance to the investment decision. Thus, by replacing the forward exchange rate \( F_t^m \) with the expected future spot exchange rate \( E[S_{t+m}] \) in (4), uncovered interest parity (UIP) is obtained:

\[
\text{UIP: } r_D - r_F = \frac{E[S_{t+m}] - S_t}{S_t}
\]

(6)

In both cases, interest rate parity argues that the country with the higher interest rate will face a depreciating currency. The interest parity conditions should hold over any period in time, which implies that the interest rate differential and the expected percentage change in the spot exchange rate should be cointegrated, i.e., moving together over time. Furthermore, if the two relationships are combined under the assumption that they both hold, it is clear that the forward exchange rate

\(^2\) To increase readability, forward premium will be used to refer to both the premium and discount.
available today $F_t^m$ must equal the expected future spot exchange rate $E[S_{t+m}]$ which is also referred to as the forward rate unbiasedness hypothesis (FRUH):

\[
\text{FRUH: } F_t^m = E[S_{t+m}] \tag{7}
\]

Moreover, most macroeconomists assume that market participants have rational expectations, i.e., that investors have perfect foresight such that $E[S_{t+m}] = S_{t+m}$ (Ferreira, 2011). Given rational expectations, FRUH is then transformed to:

\[
\text{FRUH under rational expectations: } F_t^m = S_{t+m} \tag{8}
\]

### 2.2 Interest Parity Conditions and Monetary Integration

Since CIP is more theoretically justified as it relies on the no arbitrage theorem, its empirical evidence is also stronger than its counterpart (Ferreira, 2011). Therefore, it is sound to first validate CIP before moving on to its stricter relative, UIP. In order to proceed with this transition and check the validity of UIP, both CIP and FRUH must hold as pointed out in section 2.1. Additionally, a fundamental restriction on the latter condition, FRUH, is the underlying assumption that investors are risk neutral. In order to understand any potential deviations from the FRUH, a relaxation of the risk neutrality assumption is necessary. This is done, as proposed by Fama (1984), by allowing for a foreign exchange risk premium in (7):

\[
F_t^m = E[S_{t+m}] + P_{\text{Exchange}} \tag{9}
\]

The sign of the foreign exchange risk premium gives insight on the risk attitude of investors:

\[
P_{\text{Exchange}} = \begin{cases} 
\text{risk averse,} & P_{\text{Exchange}} > 0 \\
\text{risk neutral,} & P_{\text{Exchange}} = 0 \\
\text{risk loving,} & P_{\text{Exchange}} < 0 
\end{cases} \tag{10}
\]

As empirical studies have proven that investors are risk averse, equation (7) seldom holds (Engel, 1996). It is then essential to revisit UIP using the relaxed version of FRUH in (9) in order to make a reasonable measure of monetary integration. Thus, inserting the relaxed version of FRUH in (9) into CIP in (4) gives the risk averse version of UIP:

\[
r_D - r_F = \frac{E[S_{t+m}] - S_t}{S_t} + P_{\text{Exchange}}^* \text{ Exchange, where } P_{\text{Exchange}}^* = \frac{P_{\text{Exchange}}}{S_t} \tag{11}
\]
Due to the aim for consistency in the interpretation of the interest parity conditions, a modification is also made to CIP in (4) in order to capture a country risk premium:

\[ r_D - r_F = \frac{F^m_t - S_t}{S_t} + P_{\text{Country}} \]  

(12)

It is trivial that CIP and UIP hold only when the corresponding risk premium in (11) and (12) are zero. Frankel (1992) explains that the risk premium \( P_{\text{Country}} \) in (12) accounts for country-specific risks determined by country barriers such as transaction costs, capital controls and default risk, which all restrict the capital flows in the financial markets. In other words, CIP can be interpreted as a measure of capital market mobility between two countries, where a non-existent country risk premium is equivalent to perfect capital market mobility.

The risk premium \( P_{\text{Exchange}}^2 \) in (11) can be described in a likewise manner. By replacing the forward exchange rate available today with the expected future spot exchange rate, an exposure to exchange rate risk arises which the risk premium in (11) accounts for. As long as this foreign exchange risk premium remains infinitesimal, the corresponding currencies are considered as substitutes (Holtemöller, 2005). In other words, UIP explains capital market substitutability, where perfect capital market substitutability is defined as a zero foreign exchange risk premium (Frankel, 1992). Holtemöller (2005) further states that the disappearance of this foreign exchange risk premium is one approach to evaluate monetary integration as the currencies becomes substitutes. Accordingly, this thesis will interpret monetary integration as the degree to which the foreign exchange risk premium in (11) exists.

### 2.3 Mathematical Framework

Studying interest rate parity requires estimation techniques that supersede those used in static series such as standard ordinary least squares (OLS)\(^3\). Even though most of the concepts are still useful, the estimators are seldom efficient or asymptotically normal due to the characteristics of time series data. Because of this, the methodology used to test the interest parity conditions will be modified to fit these traits. Starting with the intuition for cointegration and its requirements, focus is passed to the problems that frequently occur in estimating causal relationships using time series data and how to handle them.

---

\(^3\) Standard OLS is referred to as the simple regression of the form \( y = \alpha + X\beta + \epsilon \) where the OLS estimate of \( \beta \) is given by \( \hat{\beta} = (X^TX)^{-1}X^Ty \).
2.3.1 Unit Root Processes and Cointegration

In approaching the interest parity conditions from a dynamic view, concepts regarding the properties of the selected stochastic processes are indeed important. As the variation in time implies an increasing amount of methodological considerations, where interest rate parity only asks for some, it is beneficial to select those that are most closely aligned with the economic theory. The first such concept is *weak stationarity* which implies that the mean and variance function of a stochastic process $Y_t$ is finite. Such processes are stable, as opposed to *non-stationary* or *trending* processes (Koski, 2013). For a non-stationary stochastic process, say $X_t$, the mean and variance is changing over time and thus lack stable characteristics. Even more important, the trending component of a stochastic process is inherited so that a linear combination of a non-stationary and a stationary process will itself be a non-stationary process.

Another concept that has great importance in time series econometrics is the *order of integration* of a stochastic process, which denotes the number of times the process need to be differenced in order to become stationary. A special case often found in economics is when a stochastic process $X_t$ is integrated of order one, also denoted as $X_t \sim I(1)$. This is the case when the first difference $\Delta X_t$ (definition: $\Delta X_t = X_t - X_{t-1}$) is stationary and will from now on be referred to as the process $X_t$ having a *unit root* (Cryer & Chan, 2008). If the first difference is stationary, this is clearly equivalent to $\Delta X_t$ being integrated of order zero, i.e., $\Delta X_t \sim I(0)$. Indeed, it is also possible to study the general $d$:th order of integration case, which is significantly harder to test, but since most econometric time series are of either order one or zero such an elaboration is excluded.

Furthermore, many econometric time series share a common trend component so that the linear combination of two different but related non-stationary processes is stationary. *Cointegration* introduces the concept when two stochastic processes $Y_t \sim I(1)$ and $X_t \sim I(1)$ are both separately non-stationary and integrated of order one, but a linear combination of the two is stationary, i.e., the case when $\beta_1 Y_t + \beta_2 X_t \sim I(0)$ (Stock & Watson, 2012). As Engle and Granger (1987) argued, this is a case when two stochastic processes share a common trend and are, as they called it, cointegrated stochastic processes.\(^6\)

\(^4\) The authors revert from strict stationarity as it is seldom found in empirical work and stationarity will therefore be referred to weak stationarity throughout this thesis.

\(^5\) Including the time series studied in this thesis, stochastic processes that are $I(0)$ and $I(1)$ are of main interest to most macroeconomists as they are the most common (Campbell & Perron, 1991).

\(^6\) In general, theory allows for $n$ different stochastic processes integrated of different orders as long as the linear combination is stationary (Engle & Granger, 1987).
2.3.2 Cointegration in a Vector Framework

In order to test for the presence of cointegration between two stochastic processes $Y_t$ and $X_t$, a separate framework must be derived to find the possible stationary linear combinations mentioned in the previous section. In deriving such a framework, the starting point is to model the time-indexed variable $Y_t$ as a dependent variable and its past values $Y_{t-1}, ..., Y_{t-p}$ as independent variables. Combined with another time-indexed variable $X_t$, and adding its past values $X_{t-1}, ..., X_{t-q}$ as independent variables, this model refers to an autoregressive distributed lag (ADL) model as it takes $p$ lags of $Y_t$ and $q$ lags of $X_t$ and forms the following regression:

$$ Y_t = \lambda_1 + \phi_{11}^1 Y_{t-1} + \cdots + \phi_{11}^p Y_{t-p} + \phi_{12}^1 X_{t-1} + \cdots + \phi_{12}^q X_{t-q} + \varepsilon_{1t} \tag{13} $$

Here, $\lambda_1$ is a constant term, $\varepsilon_{1t}$ is the error term, and all other coefficients $\phi_{1j}^k$ are coefficients on the independent variables and their lags. Furthermore, a similar ADL model for $X_t$ can be introduced:

$$ X_t = \lambda_2 + \phi_{21}^1 Y_{t-1} + \cdots + \phi_{21}^p Y_{t-p} + \phi_{22}^1 X_{t-1} + \cdots + \phi_{22}^q X_{t-q} + \varepsilon_{2t} \tag{14} $$

By creating a vector out of (13) and (14) as well as introducing the constraint that the number of lags is the same on both variables, i.e., $p = q$, a vector autoregression (VAR) is introduced and is preferably condensed into matrix form:

$$ Z_t = \Lambda + \Phi_1 Z_{t-1} + \cdots + \Phi_p Z_{t-p} + \varepsilon_t \tag{15} $$

In this system, $Z_t = (Y_t, X_t)^T$ is the dependent vector, $\Lambda$ is the vector of constant terms, $\Phi_1$ are matrices of the coefficients on all lags $Z_{t-i}$ and $\varepsilon_t$ is the error term vector. According to the Granger representation theorem (Granger, 1986), for any cointegrated VAR model there exists an error correction representation so that (15) can be rewritten as:

$$ \Delta Z_t = \Lambda + \Phi Z_{t-1} + \sum_{i=1}^{p-1} \Pi_i \Delta Z_{t-i} + \varepsilon_t, \quad \text{where} \quad \Pi_i = -\sum_{j=i+1}^{p} \Phi_j \tag{16} $$

---

7 The error terms are assumed to be independent and identically distributed (i.i.d) normal random variables, i.e., $\varepsilon_t \sim N(0, \sigma^2)$. This assumption will persist throughout the thesis unless it is stated otherwise.

8 This is an equivalent form and is obtained by subtracting $Z_{t-1}$ from both sides of the VAR as well as adding first difference of each of the lags, multiplied by a decreasing adjustment factor $\Pi_i$. The adjustment factor corrects for the added differences so that (16) is equivalent to (15). For further explanation and the full proof, see Granger (1986).
Here, \( p \) is the number of lags from the VAR in (15) and \( \Phi = (\Phi_1 + \cdots + \Phi_p - I) \) is a matrix of same order as the number of included variables in the system with \( I \) as the identity matrix. This representation is referred to as the vector error correction model (VECM). In this model, the assumption of the stochastic process \( Z_t \) is that it is integrated of order one, i.e., \( \Delta Z_{t-i} \) is stationary for all \( i \), making the left hand side of (16) stationary. Because both sides should equal in order of integration and since the constant term vector \( \Lambda \) is stationary, it is evident that conditions for stationarity in the right hand side will be explained by the term \( \Phi Z_{t-1} \). This is a restriction that materializes such that \( \Phi Z_{t-1} \) need to be a vector containing stationary linear combinations of the elements in \( Z_{t-1} \). Furthermore, this restriction implies that there are three possible scenarios where \( \Phi Z_{t-1} \) is stationary:

1) When \( \Phi \) has rank zero and equals the null matrix.
2) When \( \Phi \) has full rank.
3) When the rank is less than the size of the matrix but greater than zero.

The first two cases are trivial as they either imply that there are no stationary linear combinations or that the variables are already stationary; a contradiction since \( Z_{t-1} \) is assumed to be integrated of order one. Thus, the interesting case is when the matrix has reduced but non-zero rank, more formally when \( 0 < \text{rank}(\Phi) = r < n \) where \( n \) denotes the size of the matrix. This condition implies that the rows in \( \Phi^9 \) can be rewritten as \( \beta_1 \) and \( \beta_2 \) multiplied by some adjustment coefficients \( \alpha_1 \) and \( \alpha_2 \) for each row respectively. In other words, cointegration between the variables in \( Z_{t-1} \) is present when the matrix \( \Phi \) has reduced but non-zero rank.

### 2.3.3 Heteroskedasticity and Autocorrelation in Time Series Regression

Extrapolating on standard OLS theory, regression using time series data requires modifications for inconsistencies caused by heteroskedasticity and autocorrelation as well as the non-stationarity of variables. Given that \( X \) is a vector of the included independent variables, static OLS assumptions pose restrictions on the error term of the regression where it assumed that:

1. The error term \( \epsilon_t \) has the same variance throughout all observations, i.e., \( E[\epsilon_t^2|X] = \sigma^2_\epsilon \) (homoskedasticity).
2. No autocorrelation exist between error terms, i.e., \( E[\epsilon_t \epsilon_j|X] = 0 \) (zero autocorrelation).
3. The error terms are normally distributed, i.e., \( \epsilon_t \sim N(0, \sigma^2_\epsilon) \) (normality).

---

\(^9\) The matrix \( \Phi \) can be factorized into two vectors \( \alpha \) and \( \beta \), i.e., \( \Phi = \alpha \beta^T \), that both are of dimension \((n \times r)\). This factorization is not unique and only indicates the space spanned by the cointegrating relations found in the matrix.
Drawing on these assumptions, it is clear that time series regression potentially violates some, or all, of these when variables are non-stationary. Autocorrelation and potential non-constant variance is thus a threat in time series regression and in the study of interest rate parity. Due to these characteristics of time series data, it potentially holds that:

1. Estimates of coefficients might be inconsistent.
2. Estimates of coefficients might be inefficient.
3. The hypothesis tests on these coefficients will be invalid.

When estimating coefficients in a time series regression using OLS, the most severe case occurs when the independent variables and the error term of the regression are non-stationary. This causes both the law of large numbers (LLN) and the central limit theorem (CLT) to fail, which makes OLS an inconsistent estimator and hypothesis tests on estimated coefficients invalid. When the included variables in a time series regression are non-stationary but the error term is not – the case when the variables are cointegrated – LLN holds and the OLS estimator is consistent (Murray, 2006). Furthermore, if lagged variables are included in a time series regression the coefficient of determination, R-squared, becomes an inflated measure in determining goodness of fit. Nevertheless, when the variables are cointegrated and lags are excluded from the regression, the measure is still useful in determining explanatory power of the independent variables (Cryer & Chan, 2008; Shumway & Stoffer, 2006). Because of these concerns, there are severe problems that might occur if the variables are not cointegrated or when autocorrelation is very high and it is thus of great importance to test variables for stationarity and autocorrelation before a model is fitted.

Even if it might be that the autocorrelation does not affect the consistency of OLS estimates, precautions still need to be taken due to its effect on the variance of these estimates. Namely, in the presence of autocorrelation the inconsistent variance will hurt the statistical inference on the estimated coefficients since the estimator of the variance of \( \hat{\beta} \) is biased. Because of this, it is necessary to test for autocorrelation throughout all model specifications, where the Ljung-Box

\[ R^2 = \frac{\text{explained sum of squares}}{\text{total sum of squares}} \]

Defined as the explained sum of squares over the total sum of squares in a regression, the R-squared is frequently used in time series as it is a measure of explained variance. Because of autocorrelation, lags have high explanatory power and explain the variance of dependent variable to a great extent if they are added to a time series regression. Thus, if lags of the dependent variable are included in a time series regression the R-squared will be significantly higher than regression using cross-section or panel data (Cryer & Chan, 2008).

For a full proof, see Stock and Watson (2012).
is commonly used, as well as checking the order of integration of the series, where the augmented Dickey-Fuller (ADF) test is commonly used, so that these problems can be determined early on.

2.3.4 Dynamic Estimation and Robust Standard Errors

Fortunately, there are solutions to the inefficiency and non-normality of the OLS in time series regression. If the error terms contain a stochastic trend, OLS will both be inefficient and inconsistent, but methods including differencing can be used to correct for inference (Granger & Newbold, 1974). If the included variables are cointegrated, the error term is less likely to contain a trending component and OLS will be consistent but nevertheless non-normal and inefficient (Murray, 2006). This will affect the hypothesis tests on the variables so that coefficient estimates are not asymptotically valid.

To obtain a consistent and efficient estimator in a time series regression, equivalent to maximum likelihood in the limit, Stock and Watson (1993) introduced a simple procedure in which the static OLS is augmented with leads and lags of the differenced independent variable $\Delta X_{t-i}$ as can be observed in (17). This corrects for the short-run deleterious effects that the error term $\varepsilon_t$ has on the estimates of the coefficients $\alpha$ and $\beta$ in the regression. Thus, the OLS regression $Y_t$ on $X_t$ is dynamically adjusted with observations linked to the independent variable $X_t$ in past and future periods, which is why the method is denoted as dynamic OLS (DOLS):

$$ Y_t = \alpha + \beta X_t + \sum_{i=-q}^{p} \gamma_i \Delta X_{t-i} + \varepsilon_t $$

Here, $\gamma_i$ are the coefficients on the lagged differences where $q$ is the number of leads and $p$ the number of lags included. The DOLS estimator $\hat{\beta}_{DOLS}$ of $\beta$ is consistent, efficient and asymptotically normally distributed and therefore a reliable estimator, even with autocorrelated data. Unfortunately, there is still a problem with the variance estimator in this regression. The proper adjustment for the estimator of the variance is one that adjusts for the problem caused by the relaxation of the zero autocorrelation assumption, i.e., when $E[\varepsilon_i \varepsilon_j | X] \neq 0$.

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12 It is also referred to as the Q-statistic, presented originally in Ljung and Box (1978).

13 There are many other efficient estimators such as the fully modified OLS (FMOLS) or canonical cointegrating regression (CCR). DOLS is chosen since it is an intuitive extension of standard OLS.
Since the expectation of a linear estimator is not affected by changes in the autocorrelation assumption but the variance is, an adjustment to the OLS method itself is not a solution to this inefficiency problem. Furthermore, and because it is preferred not to transform the data since a specific economic relationship is studied, the proper solution lies in adjusting the formula for the variance instead. For this purpose, Newey and West (1987) proposed a weighted correction \( f^{14} \) for autocorrelation in the variance estimator, also known as the weighted HAC estimator:

\[
Var_{NW}(\beta) = \frac{Var(X_t \varepsilon_t)}{T \times [Var(X_t)]^2} \times f, \quad \text{where} \quad f = 1 + 2 \sum_{i=1}^{m} \left( \frac{m-i}{m} \right) \hat{\rho}(i) \tag{18}
\]

Here, \( X_t \) are data from the series, \( \varepsilon_t \) are the error terms from the regression in (17) and \( \hat{\rho}(i)^{15} \) is the \( i \)th sample autocorrelation of \( X_t \varepsilon_t \). As proposed by Hansen and Hodric (1980), a truncation parameter \( m \) needs to be selected due to the inefficiency of estimating the autocorrelations well in a sample of full length \( T \). This parameter is a judgment call and is dependent on the included variables and the nature of the data. For the purpose of interest rate parity and many other economic applications, the default choice of \( m = 0.75T^{1/3} \) is recommended by Stock and Watson (2012). This estimator of the variance will be consistent when the error terms are suffering from autocorrelation and its square root is referred to as the heteroskedastic- and autocorrelation consistent standard errors (HAC standard errors).

### 2.4 A Nested Formulation for Testing Interest Parity Conditions

To answer the two questions proposed in the introduction of this thesis, a systematic approach is used, where interest rate parity will be studied at first in order to use these results to further discuss a potential Swedish EMU entry. As explained earlier, the two main proposals of interest rate parity regard when investors are either covered or uncovered in their exposure to exchange rate risk. It also became clear that if both CIP and UIP hold, the expected future spot exchange rate must in fact equal the forward exchange rate available today, i.e., FRUH must hold. Hence, there are three potential relationships to study; CIP, UIP and FRUH but only two are needed in answering the first of the two main questions.

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14 Note that \( f \) is the estimator of the autocorrelation adjustment \( f = 1 + 2 \sum_{i=1}^{m} \rho(i) \), where \( \rho(i) \) are the autocorrelations of \( X_t \varepsilon_t \).

15 The sample autocorrelation is defined as \( \hat{\rho}(i) = \frac{\hat{\gamma}(i)}{\hat{\gamma}(0)} \), where \( \hat{\gamma}(i) = \frac{1}{T} \sum_{t=1}^{T-i} (X_t - \bar{X})(X_{t+i} - \bar{X}) \) is the \( i \)th sample autocovariance.
The obvious question is which two conditions to choose. Interestingly, most studies only look at UIP, among them Kasman et al. (2008), Holtemöller (2005) and Alexius (2001). Given that UIP is the more interesting topic due to its clear-cut inference on the foreign exchange risk premium, the reason for beginning the analysis in this end is nevertheless ill-motivated as it gives no further understanding to why the condition might be rejected as it often is. Furthermore, since testing UIP requires two additional assumptions, namely, that investors have rational expectations and that they are risk neutral and because the latter is often soundly rejected in the literature (Engel, 1996), starting with CIP would give more insight into the interest parity conditions in general. Additionally, exchange rate changes are often found as stationary processes or on-the-boundary integrated of order one. Because this produces a case where a stationary variable (i.e., expected percentage change in the spot exchange rates) is regressed onto a non-stationary variable (i.e., interest rate differentials), inference on the UIP regression as well as tests for cointegration become invalid and is an \textit{a priori} sign of UIP rejection.

Due to this, there is a motivation of a nested formulation in testing interest rate parity and monetary integration where the most theoretically and empirically sound condition is tested first, CIP. After this, FRUH is tested under rational expectations in order to infer any plausible existence of UIP. In other words, the remainder of this thesis will be concerned with testing two main hypotheses regarding the interest parity conditions. The first is that CIP holds for Sweden and the EMU. The second hypothesis will be the validation of FRUH under rational expectations, which will be the equivalence of testing UIP given that CIP holds. Tying these two tests together in a discussion on monetary integration, inference on Swedish entry into the EMU will also be possible by contrasting to earlier studies.
3 Data

To study CIP with respect to Sweden and the EMU, the data under scrutiny is limited to these two markets. Apart from this, the assumption of how expectations are formed is a determinant of what data need to be looked at. Furthermore, a consistent test of CIP and FRUH needs timely data on interest rates in each economic region as well as the corresponding spot- and forward exchange rates. Adding to this, proper adjustments need to be made to fit assumptions and selected models for correct inference, which will be presented below. All data is taken from Thomson Reuters DataStream.

3.1 Spot- and Forward Exchange Rates

To obtain the forward premium, the model specification requires spot- and forward exchange rates. The data on the spot exchange rates used is the daily spot rate of Euro (EUR) to Swedish Krona (SEK). Forward exchange rates used are quoted from the British Bankers Association and the relevant series include the daily (1D), weekly (1W), monthly (1M), 2 months (2M), 3 months (3M), 6 months (6M) and yearly (12M). Since forward exchange rates are rarely issued at maturities above one year, and because their deviation from the true future spot exchange rate increases with time, it proves unwarranted to estimate CIP over horizons longer than one year and the study is limited to these series. The spot- and forward exchange rate data is taken from Thomson Reuters DataStream between the years 1999 and 2014 and produces around 4000 observations if daily data is chosen, which is preferred due to the need of a large amount of observations. The exact specification of years is ruled by the existence of the Euro and is explained in the next section. The spot- and forward exchange rates, expressed as EUR to SEK, with maturity 1D to 12M between 1999 and 2014 are illustrated in Figure 1 on the next page.

From this data, the forward premium is calculated by approximation where the log difference in the forward- and spot exchange rate is used as a surrogate for the forward premium:

\[
\text{Forward premium} \approx \log(F^m_t) - \log(S_t)
\]  

(19)

The forward premium with maturity 1D to 12M between 1999 and 2014 is shown in Figure 2 on the next page.\(^1\)

\(^1\) Furthermore, in testing FRUH, an adjustment is made for calculating the corresponding business days in the given horizons, where the assumption is that each month contains 22 business days.
Figure 1: Spot- and Forward Exchange Rates (1D-12M) from 1999 to 2014

Figure 2: Forward Premiums (1D-12M) from 1999 to 2014
3.2 Interest Rates

Choosing the right interest rates is a delicate topic in the study of interest rate parity, mainly because the existence of a time-varying risk premium might differ across markets and maturities. Because a model as close to reality as possible is preferred, including risk premiums set by the markets, interbank rates for both Swedish and European markets are chosen. Thus, the Stockholm Interbank Offered Rate (STIBOR) and the Euro Interbank Offered Rate (EURIBOR) are used and because the investment horizon need to match with the forward exchange rates, the constraint is such that only yields shorter than or equal to one year are considered. Furthermore, the dataset available is constrained to the existence of the Euro and thus only data between the introduction of the currency in 1999 and until today, 2014, are available for study. Exceptions are on the EURIBOR1D which lacks data until early 2000 and the STIBOR12M that lacks data from September 2012 for unknown reasons. Of course, it would be possible to produce a surrogate of the EURIBOR in order to artificially produce more observations, either through an aggregate rate or the German benchmark, but such an elaboration will not be considered in this thesis. Another consideration is the crisis years 2007-2008 that show evidence of significant volatility and observations that can be seen as outliers over the interval, which is why these two years are excluded in the study. This consideration was made with respect to the fact that by including the crisis years, the results were less robust and cointegration proved less likely over all series due to the change in behavior during the crisis and after. As with the data on spot- and forward exchange rates, the interest rates are taken from Thomson Reuters DataStream and are illustrated in Figure 3 and Figure 4 on the next page.

To obtain the interest rate differential, the EURIBOR is subtracted from the STIBOR and transformed to fit the investment horizon given by the forward exchange rates. Since the data is originally presented in percentage units, division by 100 is needed at first for clearer inference later on. Then, to fit the chosen investment horizon (i.e., 1D, 1W, 1M, 2M, 3M, 6M or 12M) the following formula is used:

$$\text{Interest rate differential adjusted for investment horizon} = \frac{r_{\text{STIBOR}} - r_{\text{EURIBOR}}}{d/365}$$  \hspace{1cm} (20)

Here, $d$ is the number of days in the investment horizon determined by the forward exchange rate, $r_i$ is the country-specific interbank rate and 365 represent the days in a year.
Figure 3: STIBOR (1D-12M) from 1999 to 2014

Figure 4: EURIBOR (1D-12M) from 1999 to 2014
4 Method

To perform a valid test of the CIP using a cointegration methodology, it is required that stationarity of the separate time series is tested at first. Therefore, the starting point will be to perform unit root tests of the interest rate differentials and the forward premium using the augmented Dickey-Fuller (ADF) approach. After this, the central test of cointegration is introduced where the starting point is to determine the optimal vector autoregression (VAR) model for the system using information criteria. Using the corresponding lags in the VAR model, cointegration is tested with Johansen’s maximum-likelihood method. Then, regression parameters are estimated using dynamic OLS (DOLS) to correct for inconsistencies in assumptions. Also to correct for inference, these estimates are adjusted with heteroskedasticity- and autocorrelation consistent standard errors (HAC standard errors). This approach is applied to all regressions where the variables are potentially integrated of order one, including the estimation of the CIP as well as the FRUH.

4.1 Unit Root Test

In their study on spurious regression, Engle and Granger (1987) found that cointegration can be present between two stochastic processes if they are both integrated of order one and seemingly moving together in time. Hence, in the study of CIP there is a motivation for testing the separate stationarity of the included time series. Hypothetically, both the interest rate differential and the forward premium are processes integrated of order one and indeed trending variables (Holtemöller, 2005). To test this specific behavior, the augmented Dickey-Fuller (ADF) regression is used as introduced by Dickey and Fuller (1979):

\[ \Delta X_t = \alpha + \beta_1 X_{t-1} + \gamma_1 \Delta X_{t-1} + \cdots + \gamma_p \Delta X_{t-p+1} + \epsilon_t \]  

(21)

Here, \( X_t \) is a placeholder for the interest rate differential \( R_t \) and the forward premium \( V_t \) since both series are tested separately. The null hypothesis is that the processes contain unit roots and the alternative that they are not, which is equivalent to testing \( \beta_1 = 0 \) against the alternative \( \beta_1 < 0 \) in equation (21). Depending on the proposed model of the processes, the ADF test does not have a normal distribution\(^\text{17}\) regardless of the sample size \( T \), which is accounted for in the rejection levels of the test according to MacKinnon p-values (MacKinnon, 2010). Furthermore,

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\(^{17}\) The actual distribution is chi-squared, for reference see Stock and Watson (2012).
in deciding the number of lags in the ADF test, the Akaike information criterion (AIC)\(^\text{18}\) is introduced as presented by Stock and Watson (2012). Using this criterion, the optimal amount of lags \(p\) is given by the minimized AIC value in the trade-off between estimation uncertainty and accuracy and will decide the final model of the unit root tests as well as lags in all other models.\(^\text{19}\)

### 4.2 Cointegration Test

After the hypothetical \(I(1)\) behavior has been established in the interest rate differential and the forward premium, Engle and Granger (1987) suggest that the two stochastic processes can, in some linear combination, be \(I(0)\). Since the aim is to estimate the exact number of cointegrating relationships between the variables without making any assumption of their interdependence, a VAR model is used in order to handle several relations simultaneously. By denoting the interest rate differential as \(R_t\) and the forward premium as \(V_t\), the following \(p\):th lag VAR model of the CIP relationship will be considered:

\[
\begin{pmatrix}
V_t \\
R_t
\end{pmatrix} = \begin{pmatrix}
\lambda_1 \\
\lambda_2
\end{pmatrix} + \begin{pmatrix}
\phi_{11}^1 & \phi_{12}^1 \\
\phi_{21}^1 & \phi_{22}^1
\end{pmatrix} \begin{pmatrix}
V_{t-1} \\
R_{t-1}
\end{pmatrix} + \cdots + \begin{pmatrix}
\phi_{11}^p & \phi_{12}^p \\
\phi_{21}^p & \phi_{22}^p
\end{pmatrix} \begin{pmatrix}
V_{t-p} \\
R_{t-p}
\end{pmatrix} + \begin{pmatrix}
\epsilon_{1t} \\
\epsilon_{2t}
\end{pmatrix} \quad (22)
\]

This equation can be condensed into the simpler matrix form notation:

\[
Z_t = \Lambda + \Phi_1 Z_{t-1} + \cdots + \Phi_p Z_{t-p} + \epsilon_t \quad (23)
\]

Recall that \(Z_t = (V_t, R_t)^T\) is the dependent vector, \(\Lambda\) is the vector of constant terms, \(\Phi_t\) are the matrices of coefficients on the lags \(Z_{t-1}\) and \(\epsilon_t\) is the error term vector. In this model, the optimal \(p\) amount of lag vectors need to be determined with respect to the balance of information gained from distant lags and the estimation uncertainty it produces. As in the estimation of the number of lags in the ADF test using the AIC, some information criteria need to be used to select these lags. Due to the aim for consistency of the test and in finding the optimal amount of lags, the AIC will again be considered for the VAR model. The number of lags will then be used in the Johansen specification of the cointegration test (Johansen, 1995).

---

\(^{18}\) The definition used for the AIC is as follows: \(p\) is the number of estimated coefficients, \(SSR(p)\) the sum of squared residuals, and \(T\) the number of observations, which gives \(AIC(p) = \ln(SSR(p)/T) + 2(p + 1)/T\).

\(^{19}\) AIC is preferred to the Bayes information criterion (BIC) due to the smaller increase needed in the sum of squared residuals to justify the addition of a new lag. Because of this, BIC could potentially underestimate the number of lags needed and is therefore less preferred than the AIC (Liew, 2004).
Moving on to the test of cointegration in this framework, Johansen’s method is chosen as it is more consistent than other rivals such as the EG-ADF test and need not be modified unless the variables are assumed as close-to-integrated (Hjalmarsson & Österholm, 2007). Since only fully integrated stochastic processes are considered in this thesis, such modifications will not be an issue. Considering the VAR system of the CIP relationship in (23), cointegration implies that some linear combination \( \beta_1 V_t + \beta_2 R_t \) is stationary. Since both processes are assumed to be integrated of order one and first difference stationary, it is evident that this combination must also be found in the VECM representation:

\[
\Delta Z_t = \Delta + \Phi Z_{t-1} + \sum_{i=1}^{p-1} \Pi_i \Delta Z_{t-i} + \epsilon_t, \quad \text{where} \quad \Pi_i = - \sum_{j=i+1}^{p} \Phi_j \quad (24)
\]

Recall that \( \Phi = (\Phi_1 + \cdots + \Phi_p - I) \) is a matrix of same order as the number of included variables in the system with \( I \) as the identity matrix. The requirement of cointegration, that \( \beta_1 V_t + \beta_2 R_t \) is stationary, imposes restrictions on equation (24). Because all terms except the linear combination of the included variables, \( \Phi Z_{t-1} \), are \textit{a priori} stationary, these restrictions materialize such that \( \Phi Z_{t-1} \) need to be a stationary linear combination of the elements in \( Z_{t-1} \). The number of linear combinations that can be found equals the rank of the matrix \( \Phi \), where rank one implies cointegration between the interest rate differential and the forward premium.

Using a key result from linear algebra, that the rank of a matrix equals the number of non-zero eigenvalues, cointegration between the variables can be tested. A sequential procedure is developed to test the rank of the matrix \( \Phi \) and for this purpose, the \( r \)-th rank hypothesis denoted \( H(r) \) is formulated. For all possible ranks \( k = 0, \ldots, n \) of the matrix \( \Phi \) in (24), the null hypothesis \( H_0(r \leq k) \) is tested against the alternative \( H_1(r > k) \) for all \( k \). In the Johansen specification, likelihood ratio (LR) tests are consulted to determine the rank of \( \Phi \). Since the rank of a matrix is equal to the number of non-zero eigenvalues, the LR tests are based on the estimated eigenvalues \( \hat{u}_1, \ldots, \hat{u}_n \) of the matrix \( \Phi \), which all lie between zero and one.\(^{20}\) Then, the trace statistic \( LR_{Trace}(k) = -T \sum_{i=k+1}^{n} \ln(1 - \hat{u}_i) \) is used to test hypothesized rank values in the derived sequence.\(^{21}\)

\(^{20}\) When the eigenvalues are close to zero, the trace statistic is very small and the opposite occurs when they are close to one. A full account of cointegration in the VECM framework can be found in Johansen (1995).

\(^{21}\) Since the test is based on the ordered feature of the eigenvalues, if the rank equals \( k \) then all following eigenvalues should be close to zero and the trace statistic small as \( \ln(1 - \hat{u}_i) \) is approximately zero for \( i \) greater than \( k \).
4.3 Covered Interest Parity Regression

To estimate the direct relationship between the interest rate differential and the forward premium, Alexius (2001) proposes OLS as a natural procedure to estimate a model for interest parity coefficients. Because there is economic motivation\(^{22}\) for the forward premium \(V_t\) being the dependent variable, single-equation OLS estimation of coefficients is preferred to a VAR estimation, which also produces easier interpretation. Although a VAR estimation will be made in order to proceed with tests for cointegration using Johansen’s method, the single-equation OLS regression is preferred due to the ease of interpretation and due to the environment in which the results of this thesis are presented. Since the coefficient estimates in a standard OLS regression are inefficient, a DOLS regression will be applied to CIP by including leads and lags of the differenced interest rate differential \(\Delta R_t\):

\[
V_t = \alpha + \beta R_t + \sum_{i=-q}^{p} \gamma_i \Delta R_{t-i} + \varepsilon_t
\]

Recall that \(\gamma_i\) are the coefficients on the leads \(q\) and lags \(p\) and \(\varepsilon_t\) the error term. Following this procedure, the slope coefficient \(\beta\) on the interest rate differential and the constant term \(\alpha\), equivalent to the country risk premium, can both be estimated with valid statistical inference where interest rate parity implies a hypothetical constant term \(\alpha\) of zero and a slope coefficient \(\beta\) of one for CIP to hold. Of course, t-statistics, p-values and confidence intervals still need to be calculated using the HAC standard errors due to the non-stationary characteristics of the variables.

4.4 Forward Rate Unbiasedness Hypothesis Regression

As proposed in section 2.1, the link between CIP and UIP is the assumption of how expectations are formed in the market. Specifically, given that CIP holds it must be that \(F_t^m = E[S_{t+m}] = S_{t+m}\), i.e., FRUH holds under rational expectations, for the plausible existence of UIP. Indeed, such a relationship is easily tested using OLS techniques as discussed earlier. For perfect inference on UIP and monetary integration, there is a motivation for regressing the future spot

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\(^{22}\) In most economic regimes, central banks set interest rates according to the current level of inflation and unemployment which motivates the independence of the interest rate differential to the forward premium. Furthermore, the Swedish Central Bank followed exchange rate targeting until the banking crisis in 1992 but have ever since followed a monetary policy of inflation targeting (Nessén et al., 2011).
exchange rate on today’s forward exchange rate with another parameter representing the foreign exchange risk premium. It stands to reason that in setting forward exchange rates, the future spot exchange rate is simply not known today and implies that there can be no causality running from the future spot exchange rate to the forward exchange rate set today. Thus, the spot exchange rate is modeled as the dependent variable and the forward exchange rate as the independent variable in this regression. To adjust for deleterious effects caused by the non-stationary characteristics of the included variables, DOLS will also be applied to this regression:

\[ S_{t+m} = \alpha + \beta F_t^m + \sum_{i=-q}^{p} \gamma_i \Delta F_{t-i}^m + \epsilon_t \]  

The aim of this regression is to estimate the constant term \( \alpha \), the slope coefficient \( \beta \) and the number of leads \( q \) and lags \( p \) on the forward exchange rate as well as the corresponding coefficients \( \gamma_i \). As usual, \( \epsilon_t \) is the error term. In performing this regression, inference is drawn on the FRUH condition under rational expectations where the strict requirement for UIP to hold, given that CIP also holds, is that \( \beta = 1 \) and the foreign exchange risk premium \( \alpha = 0 \). Using the techniques developed earlier, this will be tested using HAC standard errors for correct inference. The results from this regression, along with the aforementioned tests, are presented in section 5.

4.5 Qualitative Methodology

As a final methodological concern, the results produced from the econometric framework need to be linked to current literature. To be able to draw any inference on the economic impact or even gain an understanding of the quantitative results, that supposedly should answer question 1) “Does the covered- and uncovered interest rate parity condition hold between Sweden and the EMU?” and provide a segue to 2) “Is there evidence of monetary integration between the two regions that could motivate a Swedish entry into the EMU?”, there is indeed a strong need for qualitative studies on the subject. The qualitative analysis embarked in past studies on CIP, UIP and FRUH, which also relates the method chosen in this thesis to those of other studies. These studies were found by searching

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23 The Siegel Paradox (Siegel, 1972) states that the forward exchange rate cannot be an unbiased estimator for both numeraires simultaneously and is commonly solved using logarithms. However, the authors revert from the use of logarithms as the paradox is purely a mathematical inconveniency and irrelevant for empirical work (Roper, 1975).

24 This part is, according to the authors, indeed a very superfluous section that would be better off left outside of this thesis. It stands to reason that any academic would include qualitative studies in their research on an economic relationship, or any other topic for that matter, and stating so is evidently obvious. Nevertheless, this is a requirement for thesis submission and will thus be included.
databases\textsuperscript{25}, where HKUST Library, KTH Library and of course the web were used. The resources provided an extensive base for discussion where those articles that aligned closely with the method presented in this paper were chosen. Additionally, those articles that were specific to Sweden and the EMU had a greater priority than similar articles for other countries.

Past studies are quite diverse in the methods used, but as in most recent economic papers they are of a quantitative nature as opposed to qualitative. Common for most articles is the use of time series to study the dynamic relationships, whether it is solely cointegration of interest rates (Reade & Volz, 2009) or testing UIP (Alexius, 2001) all data used is on this form. Monetary integration, on the other hand, is usually studied with the UIP condition in mind (Ferreira, 2011; Kasman et al., 2008; Holtemöller, 2005) or simply by looking at the co-movement of interest rates (Buscher & Gabrisch, 2011; Reade & Volz, 2009). Thus, to build a discussion on the topic it has been helpful to look at the common traits and what possible inference the results from this thesis can give rise to.

The linkage to monetary integration was studied extensively in order to provide groundwork for the discussion on the topic. In doing this, it was necessary to look at how researchers interpreted the interest parity conditions, the corresponding risk premiums and connection to monetary union and integration. It is also worth to mention that a large amount of the knowledge needed was accumulated through several courses in economics, where those in macroeconomics and other thesis work in the subject of cointegration have been most useful. Furthermore, discussion with practitioners\textsuperscript{26} in applied economic work has been made to gain a broader perspective on the relevance of CIP and UIP. Ultimately, all of these aspects have helped in the development and discussion of both questions in the thesis and how to integrate them.

\textsuperscript{25} The keywords used were mainly: Interest Rate Parity (IRP), Covered Interest Parity (CIP), Uncovered Interest Parity (UIP), Forward Rate Unbiasedness Hypothesis (FRUH), Monetary Integration, Sweden, EMU, STIBOR, EURIBOR, Cointegration, Johansen Test, Dynamic OLS.

\textsuperscript{26} Thanks goes to Ånnika Alexius, Visiting Professor at the Department of Economics at Stockholm University for her input on the macroeconomic inference of CIP and UIP.
5 Results

Since the focus lies on the hypothesis tests of coefficients in the earlier derived regressions, there will be less focus on forecasting and exact model specifications (i.e., lags by AIC, VAR estimation, R-squared) but more on significance tests. Following up on the methodology derived in section 4, the results from the data are presented in a similar manner. As they are a requirement for time series studies, the unit root tests are presented first. This is also due to the fact that the separate behavior of the series determines whether cointegration and further regression analysis can be studied. After these results are presented, and the selection of non-stationary series is made, the results from the cointegration tests follow and closely after these tests are the DOLS estimations of CIP. Lastly, the FRUH regression results are looked at along with some robustness checking of CIP before and after the global financial crisis 2007-2008.

5.1 Unit Root Tests

Even though there is a motivation for assuming unit roots rather than performing tests to check that the data series inhibit such characteristics, as a minimum requirement it is preferable to test for autocorrelation between observations before using any techniques in cointegration (Sjö, 2008). In doing so, the Ljung-Box test show evidence of autocorrelation in all series except for the shortest forward premium data. Even though there is a strong need for unit root tests on the forward premium series. Furthermore, unit root tests on the interest rate differential are also conducted to maintain consistency of method.

<table>
<thead>
<tr>
<th>Time horizon</th>
<th>Null hypothesis</th>
<th>ADF t-statistic</th>
<th>p-value*</th>
<th>Lags</th>
</tr>
</thead>
<tbody>
<tr>
<td>1D</td>
<td>$\beta_1 = 0$</td>
<td>-11.58573</td>
<td>0.0000</td>
<td>26</td>
</tr>
<tr>
<td>1W</td>
<td>$\beta_1 = 0$</td>
<td>-12.29927</td>
<td>0.0000</td>
<td>15</td>
</tr>
<tr>
<td>1M</td>
<td>$\beta_1 = 0$</td>
<td>-6.369391</td>
<td>0.0000</td>
<td>27</td>
</tr>
<tr>
<td>2M</td>
<td>$\beta_1 = 0$</td>
<td>-3.619394</td>
<td>0.0055</td>
<td>27</td>
</tr>
<tr>
<td>3M</td>
<td>$\beta_1 = 0$</td>
<td>-2.592365</td>
<td>0.0946</td>
<td>27</td>
</tr>
<tr>
<td>6M</td>
<td>$\beta_1 = 0$</td>
<td>-1.661360</td>
<td>0.4509</td>
<td>27</td>
</tr>
<tr>
<td>12M</td>
<td>$\beta_1 = 0$</td>
<td>-1.525580</td>
<td>0.5207</td>
<td>15</td>
</tr>
</tbody>
</table>

*The null hypothesis is that the forward premium is integrated of order one.


By performing ADF tests on the 1D, 1W, 1M, 2M, 3M, 6M and 12M forward premium, it is evident that the predicted difference between the current and future spot exchange rate increases over time. This can be seen as a stronger trend in the forward premium as time distance between today’s spot exchange rate and the future date on the forward exchange rate increases. As can be

27 The autocorrelation tests are excluded from the results but are, of course, available on request.
observed in Table 1, the shortest series test with an ADF t-statistic of -11.59 that amount to a p-value of 0.000. This soundly rejects the null hypothesis of a unit root in the 1D series since a smaller ADF t-statistic implies stronger rejection (MacKinnon, Haug, & Michelis, 1996). The day-to-day forward premium is therefore accepted as integrated of order zero and a stationary process. The same result is found for 1W, 1M and 2M where all reject the null hypothesis of a unit root, which implies that the shorter forward premium are relatively more random. Since cointegration methods does not apply for stationary variables, such tests for cointegration cannot be performed on the shorter series 1D, 1W, 1M as well as 2M.

Looking at the forward premium over three months, the 3M series, the result is more promising as the null hypothesis of a unit root cannot be rejected at the 5% significance level. With an ADF statistic of -2.59 and a corresponding p-value of 0.095, the 3M series is accepted weakly as integrated of order one. This is also found for 6M and 12M where the unit root is accepted with even stronger p-values around 0.45-0.52 and cointegration methods are thus applicable for these series. Furthermore, the number of lags chosen by AIC is relatively stable over all series but show evidence of a lacking amount of information in each lag as the estimated lags are 15-27 for all series. Again, this is not surprising since the underlying processes are random and close-to stationary which implies that the differences of the series are relatively uncorrelated.

Table 2: Unit Root Tests for Interest Rate Differential

<table>
<thead>
<tr>
<th>Time horizon</th>
<th>Null hypothesis</th>
<th>ADF t-statistic</th>
<th>p-value</th>
<th>Lags</th>
</tr>
</thead>
<tbody>
<tr>
<td>1D</td>
<td>$\beta_t = 0$</td>
<td>-2.163123</td>
<td>0.2202</td>
<td>24</td>
</tr>
<tr>
<td>1W</td>
<td>$\beta_t = 0$</td>
<td>-2.022323</td>
<td>0.2773</td>
<td>18</td>
</tr>
<tr>
<td>1M</td>
<td>$\beta_t = 0$</td>
<td>-1.994212</td>
<td>0.2896</td>
<td>3</td>
</tr>
<tr>
<td>2M</td>
<td>$\beta_t = 0$</td>
<td>-1.881809</td>
<td>0.3412</td>
<td>2</td>
</tr>
<tr>
<td>3M</td>
<td>$\beta_t = 0$</td>
<td>-1.868252</td>
<td>0.3477</td>
<td>2</td>
</tr>
<tr>
<td>6M</td>
<td>$\beta_t = 0$</td>
<td>-1.916159</td>
<td>0.3250</td>
<td>2</td>
</tr>
<tr>
<td>12M</td>
<td>$\beta_t = 0$</td>
<td>-2.226578</td>
<td>0.1969</td>
<td>1</td>
</tr>
</tbody>
</table>

*The null hypothesis is that the interest rate differential is integrated of order one.

As for the interest rate differential, there is no evidence for a rejection of the unit root assumption in either of the series as can be observed in Table 2. The strongest acceptance of the null hypothesis is found in the 3M series with an ADF t-statistic of -1.87 and a p-value of 0.35. Following 3M is the 2M differential that accepts the unit root with a p-value of 0.34 and closely after is 6M. Thus, all interest rate differentials are assumed to be integrated of order one and hence non-stationary. Adding to this, the number of lags needed in the ADF regressions also decrease for each series where the AIC suggest 24 on 1D down to 1 lag for the yearly interest rate

28 These p-values change with the ADF regression specification and we will simply state the p-values under the null hypothesis. The exact specification and motivation can be found in MacKinnon et al. (1996).
differential. This is also expected since the longer interest rate series are relatively more constant and slowly moving in time as these rates are changing less often. This implies that the number of lags for these series is less due to the capture of distant information in recent lags.

The results from the unit root tests speak for a case where cointegration cannot be tested on the shorter horizons due to the stationarity of the forward premium in 1D, 1W, 1M and 2M. The difference in order of integration is also a problem in the CIP regression since the relationship in levels between the interest rate differential and forward premium is, then, no longer linear. For these reasons, the CIP regression is ignored for the shorter horizons. In other words, cointegration relationships, which are tested in the next part, can only potentially be found in 3M, 6M and 12M.

5.2 Cointegration Tests

Drawing on the results from the unit root tests, cointegration tests on 1D, 1W, 1M and 2M are ill-specified\(^\text{29}\) as these forward premium series are stationary. Hence, results will only be studied for the non-stationary series 3M, 6M and 12M. In the search for a cointegrating relationship between the interest rate differential and the forward premium, there is evidence of a relationship in all three series. As introduced in section 4.2, the number of cointegrating relations is tested in a sequential hypothesis where zero relations against greater than one relation is tested at first. Using the Johansen unrestricted rank test on the trace of the estimated matrix \(\Phi\) in equation (24), inference can be drawn on the number of cointegrating relations in the system (Johansen, 1995). Due to its similarity with the ADF test for unit roots, the p-values of the trace statistics follow MacKinnon-Haug-Michelis p-values but these critical values might differ between model specifications (MacKinnon et al., 1999). Because all VECM estimations produced the same amount of lags in all three specifications, the critical values for the rank tests are conveniently the same for all of them and are estimated as 15.49 for no cointegrating relations and 3.84 for at most one relationship at the 5% significance level. This is illustrated in Table 3 below.

<table>
<thead>
<tr>
<th>Time horizon</th>
<th>Null hypothesis</th>
<th>Eigenvalue</th>
<th>Trace statistic</th>
<th>0.05 critical value</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>3M</td>
<td>(r \leq 0)</td>
<td>0.011471</td>
<td>42.46572</td>
<td>15.49471</td>
<td>0.0000</td>
</tr>
<tr>
<td></td>
<td>(r \leq 1)</td>
<td>0.000879</td>
<td>3.007329</td>
<td>3.841466</td>
<td>0.0829</td>
</tr>
<tr>
<td>6M</td>
<td>(r \leq 0)</td>
<td>0.006862</td>
<td>26.30203</td>
<td>15.49471</td>
<td>0.0008</td>
</tr>
<tr>
<td></td>
<td>(r \leq 1)</td>
<td>0.000804</td>
<td>2.751805</td>
<td>3.841466</td>
<td>0.0971</td>
</tr>
<tr>
<td>12M</td>
<td>(r \leq 0)</td>
<td>0.000036</td>
<td>19.48414</td>
<td>15.49471</td>
<td>0.0119</td>
</tr>
<tr>
<td></td>
<td>(r \leq 1)</td>
<td>0.000395</td>
<td>1.193157</td>
<td>3.841466</td>
<td>0.2747</td>
</tr>
</tbody>
</table>


\(^{29}\) Two series must both be integrated of the same order to be cointegrated (Engle & Granger, 1987).
For 3M, 6M and 12M, there is evidence that the interest rate differential is cointegrated with the forward premium. The 3M series draw a trace statistic of 42.47, exceeding the 5% significance level critical value for the null hypothesis of zero relations, amounting to a p-value of 0.000 of the system containing no cointegrating vectors. The same is found for the 6M and 12M series with trace statistics of 26.30 and 19.48 and corresponding p-values of 0.001-0.012. Indeed, there is evidence of all systems rejecting zero cointegrating relations in the matrix and motivates the test of at most one relation in the system as a continuation of the sequential hypothesis formulation. Finding from the second null hypothesis that at most one cointegration relation exists in the system, cointegration cannot be rejected for the 3M, 6M and 12M series. With trace statistics below the critical value of 3.842, the p-values of the null hypothesis materialize in 0.083 for 3M, 0.097 for 6M and 0.275 for 12M. This points to a case where there is evidence of cointegration between the interest rate differential and the forward premium for all three series, indeed a positive result for CIP and allows for further interpretation.

5.3 Covered Interest Parity Regressions

As explained in footnote 22, economic theory suggests that the exchange rate is a function of the interest rate more so than vice versa. Due to this, the dependent variable in the CIP regression will be the forward premium and not the interest rate differential, which instead will act as an independent variable together with a constant term determining the existence of any country risk premium. Furthermore, CIP implies this estimated country risk premium $\alpha = 0$ and the slope coefficient on the interest rate differential $\beta = 1$. Thus, by looking at the DOLS regression results in Table 4 to Table 6 below, it will be possible to draw conclusions on CIP as explained earlier.

Table 4: CIP Regression for 3M

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Null hypothesis</th>
<th>Coefficient</th>
<th>HAC standard error</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country risk premium</td>
<td>$\alpha = 0$</td>
<td>0.000015</td>
<td>0.000047</td>
<td>0.322034</td>
<td>0.7474</td>
</tr>
<tr>
<td>STIBOR3M-EURIBOR3M</td>
<td>$\beta = 1$</td>
<td>0.944676</td>
<td>0.027072</td>
<td>-2.04387</td>
<td>0.0411</td>
</tr>
</tbody>
</table>

Summary statistics:
- R-squared: 0.361400
- Adjusted R-squared: 0.35346
- Standard error of regression: 0.002159
- Number of observations: 3408
- Leads: 1

Table 5: CIP Regression for 6M

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Null hypothesis</th>
<th>Coefficient</th>
<th>HAC standard error</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country risk premium</td>
<td>$\alpha = 0$</td>
<td>0.000010</td>
<td>0.000053</td>
<td>0.188065</td>
<td>0.8508</td>
</tr>
<tr>
<td>STIBOR6M-EURIBOR6M</td>
<td>$\beta = 1$</td>
<td>1.016747</td>
<td>0.016302</td>
<td>-1.207297</td>
<td>0.2244</td>
</tr>
</tbody>
</table>

Summary statistics:
- R-squared: 0.589884
- Adjusted R-squared: 0.585996
- Standard error of regression: 0.002595
- Number of observations: 3408
- Leads: 1

27
Table 6: CIP Regression for 12M

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Null hypothesis</th>
<th>Coefficient</th>
<th>HAC standard error</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country risk premium</td>
<td>$\alpha = 0$</td>
<td>0.000290</td>
<td>0.000086</td>
<td>3.360371</td>
<td>0.0008</td>
</tr>
<tr>
<td>STIBOR12M - EURIBOR12M</td>
<td>$\beta = 1$</td>
<td>0.990506</td>
<td>0.013021</td>
<td>-0.729130</td>
<td>0.4660</td>
</tr>
</tbody>
</table>

Summary statistics

<table>
<thead>
<tr>
<th></th>
<th>Numbers of:</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-squared</td>
<td>Observations</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>Leads</td>
</tr>
<tr>
<td>Standard error of regression</td>
<td>Lags</td>
</tr>
</tbody>
</table>

As the unit root tests suggested, the 1D, 1W, 1M and 2M series are ill-suited for regression due to the difference in order of integration of the included series. By continuing with 3M, 6M and 12M only, there is evidence of an increasing predictability of the forward premium using the interest rate differential since the R-squared\(^{30}\) is increasing in a linear manner over the three regressions as shown in the tables above. Starting from a relatively low value of 0.36 for 3M, the R-squared increases to 0.59 for 6M and peaks at 0.64 for the yearly series which speaks for a higher explanatory power for these longer horizons. The less explanatory power for the shorter time frame might be caused by the minimal movement of interest rates on a shorter horizon, which also can be seen in Figure 3 and Figure 4 from the data section as a relatively constant differential for these time frames.

The estimated constants and slope coefficients on the interest rate differential is presented in the tables above, where a slope coefficient on the interest rate differential equaling one can be accepted for all three series at the 5% significance level except 3M which rejects with a p-value of 0.04. The results from the longer time frames seem more robust as the HAC standard errors are smaller and diminishing on the constant for these estimations. For 6M and 12M, the estimated coefficients on the interest rate differentials are not rejected as unit with p-values of 0.30 and 0.47 respectively. As for the estimated constant term in the regression for 3M and 6M, zero is strongly accepted with p-values of 0.75 and 0.85 which can be explained by a smaller country risk premium for shorter horizons. The 12M series, though, show evidence of a non-zero constant in the regression as the estimated p-value is close to zero. This speaks for a case where CIP holds in the strict sense, i.e., $\alpha = 0$ and $\beta = 1$ for 6M only. For 3M, a zero constant is accepted but nevertheless the coefficient on the interest rate differential is non-unit, a result that rejects the conditions for CIP. The same rejection of CIP can be found for 12M if the condition is defined strictly with a zero-mean country risk premium. Since small allowances could be made for a non-zero country risk premium, CIP is weakly accepted for 12M as the forward premium reflects the interest rate differential when $\beta = 1$.

\(^{30}\) However, R-squared should be used with caution since it increases with additional lags, namely the case in DOLS regression.
5.4 Forward Rate Unbiasedness Hypothesis Regressions

Under the assumption that investors have rational expectations, the link between CIP and UIP is given by the forward- and spot exchange rates and how well they correlate with each other. More specifically, if CIP holds it must be that the forward exchange rate is a perfect predictor of the future spot exchange rate, i.e., that FRUH holds under rational expectations, which is a relationship simply tested by OLS. By regressing the future spot exchange rate on the forward exchange rate available today, the inference on any estimated constant will be that of a foreign exchange risk premium. This premium is, then, important in the interpretation of the risk attitude of investors. The condition of strict equality implies that any such premium must be zero as well as the estimated slope coefficient on the future spot exchange rate is one.

By regressing using DOLS and HAC standard errors, it is evident that the forward exchange rate is losing predictability as the time span increases which can be observed in Table 8 to Table 14 in Appendix A. Apart from the estimated coefficients, this fact is indeed evident in the estimated R-squared of the regression as it also decreases with each time horizon when the model specification remains the same. Starting close to unit for the daily FRUH regression, it decreases to 0.48 for 6M and down to 0.12 in the yearly FRUH regression. The same pattern can be discerned in the coefficient estimates where the null hypothesis on the constant term as well as the slope coefficient on the forward exchange rate cannot be rejected for either the daily or the weekly forward exchange rate with p-values around 0.19-0.62 and 0.21-0.60 for each respectively. For all other horizons, though, both the null hypothesis of a constant of zero and a slope coefficient of one is strongly rejected at the 5% significance level, except for 1M where the slope coefficient is rejected at the 10% significance level.

These results imply that the forward exchange rate is a reliable predictor of the future spot exchange rate for 1D and 1W, i.e., that the daily and weekly forward exchange rate is a good predictor of the spot exchange rate over a day or week respectively. For periods longer than one week though, it is not. This indicates that UIP could hold for 1D or 1W but is strictly rejected for all other time horizons. Since the CIP regression is ill-specified for the shorter horizons when the interest rate differential and the forward premium are integrated of different orders, no inference can be made on UIP using FRUH for these horizons without further modifications or a change in assumptions.

31 Unit root tests on the forward- and spot exchange rates show evidence of stationarity in all series. ADF tests lie on the boundary of rejection at the 5% level, but are more robust at the 10% level where strict rejection of non-stationarity is possible. Hence, DOLS can be performed but with caution. Test results are presented on request.
5.5 Pre- and Post-crisis of Covered Interest Parity

Realizing that the crisis years may affect the relationships studied, tests before and after the financial crisis are necessary to deduce the robustness of the estimated results. Assuming that the order of integration is preserved over the whole period, it can be inferred that the separate periods pre- and post-crisis follow the same characteristics and new stationarity tests are thus not needed. In the same line of reasoning, cointegration relationships are also assumed to persist for these shorter periods and will also not be tested. Robustness will only be studied for the CIP regression for time horizons 3M, 6M and 12M for reasons explained earlier.

Interestingly, as Table 15 to Table 20 in Appendix A illustrate, CIP does not seem to hold for either the pre- or post-crisis period. In the aftermath of the financial crisis, the estimated coefficients show values far lower than over the whole period while the opposite is true for the estimated pre-crisis coefficients. The post-crisis 3M, 6M and 12M regressions all produce coefficients on the interest rate differential in the area 0.58-0.76, whereas the pre-crisis regressions yield estimates around 1.07-1.18. For both periods, p-values on the slope coefficients imply that the null hypothesis of one is soundly rejected. Additionally, t-tests also yield that these estimates, pre- and post-crisis coefficients, are significantly different from each other.\(^{32}\) This result speaks for a shift in market behavior from before to after the crisis, a highly interesting feature of the study.

The country risk premium, i.e., the estimated constant of the CIP regression, also seems to produce non-zero estimates both before and after the financial crisis. With a statistically significant estimate different from zero, post-crisis estimates yield a constant around 0.0001-0.004 and pre-crisis all negative estimates around -0.0003-(-0.00009). Again, this result is very interesting as the pre- and post-crisis estimates seem to be each other’s opposites, a result that also speaks for a shift in behavior of the market after the crisis.

As it turns out, then, the periods before and after the crisis seem to be very different with respect to CIP. The pre-crisis period produces coefficients on the interest differential significantly higher than the required unit, and constants significantly lower than zero as CIP suggests. Post-crisis estimates, on the other hand, yield coefficients significantly lower than unit and constants higher than CIP suggests. This could explain the satisfactory results for some series in the CIP

\(^{32}\) To obtain the test of difference, a t-test is made for both periods with the null hypothesis that the estimated values in one period equals the estimated values in the other period.
regression over the whole period, as the pre- and post-crisis estimates cancel out over the whole period. Nevertheless, this discrepancy before and after is a negative result in the study of CIP as it implies that deviations from the theory occur in the short-run. Fortunately, relationships such as CIP are best studied over longer periods since local disturbance might occur due to business cycles and country-specific trends. Thus, these estimates of the CIP regression are less reliable than those obtained from the whole period.

5.6 Summary of Results

Table 7: Summary of Findings

<table>
<thead>
<tr>
<th>Time horizon</th>
<th>I(1) variables</th>
<th>Cointegrated</th>
<th>CIP holds</th>
<th>FRUH holds</th>
<th>UIP holds</th>
<th>CIP pre- vs. post-crisis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1D</td>
<td>No</td>
<td>N/A</td>
<td>Yes</td>
<td>No***</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>1W</td>
<td>No</td>
<td>N/A</td>
<td>Yes</td>
<td>No***</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>1M</td>
<td>No</td>
<td>N/A</td>
<td>No*</td>
<td>No***</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>2M</td>
<td>No</td>
<td>N/A</td>
<td>No</td>
<td>No***</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>3M</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Significant</td>
<td></td>
</tr>
<tr>
<td>6M</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Significant</td>
<td></td>
</tr>
<tr>
<td>12M</td>
<td>Yes</td>
<td>Yes*</td>
<td>Yes</td>
<td>No</td>
<td>Significant</td>
<td></td>
</tr>
</tbody>
</table>

*If a small, non-zero country risk premium is accepted.
**:If the 10% significance level is chosen for the slope coefficient.
***Unit root tests on the expected spot exchange rate change are stationary.

The results from all tests are summarized above in Table 7 for easier interpretation, where the nested sequence for testing interest rate parity can be noted from left to right. The ADF tests found that only three out of the seven horizons showed unit root behavior, a prerequisite for CIP to hold. This resulted in four series that could not be further tested for the CIP condition. As for the three series that showed unit roots, all of them were cointegrated and fulfill the prerequisite for CIP. The direct estimation of the coefficients, though, showed satisfactory results only for 6M and partially for 12M if a small country risk premium is allowed. From these last two regressions together with the results from the FRUH regression respectively, it can be inferred that UIP strictly does not hold for these horizons. Furthermore, for all other horizons where the interest rate differential and the expected spot exchange rate change, or forward premium correspondingly, are integrated of different orders, it can be inferred that none of the interest parity conditions can hold. Since the interest rate differential is integrated of order one whereas the expected percentage change in the spot exchange rate is integrated of order zero, neither cointegration or a properly specified regression can be established for UIP and it is therefore unlikely to hold given the data. Additionally, the robustness tests checking pre- and post-crisis yielded significant differences before and after the global financial crisis in 2007-2008.

ADF tests show that the expected spot exchange rate change is stationary for all horizons except for 12M. This implies that a test for UIP is ill-specified since the interest rate differential is non-stationary, whereas the expected spot exchange rate change is stationary, and there cannot exist any long-run equilibrium. Since CIP holds for 6M and weakly for 12M but FRUH does not, it can therefore be inferred that UIP does not hold for any horizon.
6 Discussion

In answering the original two questions laid out in this thesis, 1) “Does the covered- and uncovered interest parity condition hold between Sweden and the EMU?” and 2) “Is there evidence of monetary integration between the two regions that could motivate a Swedish entry into EMU?”, the results in section 5 give a solid basis on which economic interpretations can be built. Since there are more to the interest parity conditions to discuss than their sole rejection or acceptance, the discussion will embark in a thorough analysis of the economic implications of the regression results on interest rate parity as well as FRUH to answer the former question. Secondly, these results are related to what other authors find interesting in studies on monetary integration and contrasted with past discussions on Swedish EMU entry to ultimately find an answer to the latter question.

6.1 Interest Parity Conditions and Forward Rate Unbiasedness Hypothesis

Of those time horizons that the interest rate differential and the forward premium both contain unit roots, the tests show evidence of cointegration. This indicates that there exists a plausible environment for the CIP condition to hold, even if there might exist short-term disturbances. These short-term disturbances were not found to be significant as the residuals proved to be stationary and normally distributed, i.e., seen as noise, which is in line with economic theory as opportunities for arbitrage should vanish quickly and occur on a highly random basis. What is interesting though, is that cointegration is stronger for the longer horizons. There are some possible explanations of this phenomenon and the most probable is in the same line of reasoning as just discussed; that anomalies occur on a short-term basis and vanish in the long-run. Furthermore, the interest rate differentials and forward premiums are more likely to deviate from long-run states in the short-run, which implies that the processes might show characteristics different from their true behavior in finite samples (Vasicek, 1977). As can be seen from the plotted graphs of the series in Figure 5 to Figure 11 in Appendix B, the more volatile process is the forward premium and for the shorter horizons this effect might even be the main cause of its unit root rejection. Over longer horizons, the process shows more trending behavior that might cointegrate with the interest rate differential as it evidently does. Thus, cointegration is reasonably lower for shorter time horizons as the results in section 5.2 suggest.

Extrapolating on this reasoning, this might also suggest a reason for the common finding in the literature that both CIP and UIP tend to hold more frequently for longer horizons (Ferreira, 2011; Alexius, 2001). In the short-run, it is evident that deviations are caused by disturbances
from the error term as well as a time-varying risk premium. Because these two are hard to separate empirically, and because both parity conditions require a finite risk premium, it stands to reason that both CIP and UIP will fail more often in the short- relative to the long-run. Furthermore, these disturbances average out and lack significance in the long-run, which implies that the risk premium is approaching its true behavior as horizon increases. Thus, both conditions are not only more likely to hold for longer horizons, but any results obtained from these horizons will also be more reliable.

Moving on to the CIP condition itself, recall that the country risk premium is on the opposite side in equation (12) compared to that in the regression model of (25), which means that it is necessary to change the sign of estimated country risk premium for correct economic interpretation, i.e., \( p_{\text{country}} = -\alpha \). Inserting estimated values for \( \alpha \) and \( \beta \) obtained from the tables in section 5.3 gives the specific values for 3M to 12M:

\[
3M: \quad \log(F_t^{3M}) - \log(S_t) = \frac{0.000015}{(0.000047)} + \frac{0.944676}{(0.027072)} \left( r_{\text{STIBOR3M},t} - r_{\text{EURIBOR3M},t} \right) \\
6M: \quad \log(F_t^{6M}) - \log(S_t) = \frac{0.000010}{(0.000055)} + \frac{1.016747}{(0.016302)} \left( r_{\text{STIBOR6M},t} - r_{\text{EURIBOR6M},t} \right) \\
12M: \quad \log(F_t^{12M}) - \log(S_t) = \frac{0.000290}{(0.000086)} + \frac{0.990506}{(0.013021)} \left( r_{\text{STIBOR12M},t} - r_{\text{EURIBOR12M},t} \right)
\]

The inverted risk premium \( \alpha \) is positive and increasing for each time horizon in the three regressions above. This means that the country risk premium is more negative for longer horizons. According to Frankel (1991), the sign of the country risk premium gives insight into the nature of capital market mobility. More specifically, a negative country risk premium implies that domestic country barriers discourage the capital to flow out from the country. Since the standard errors in the parentheses in (27) and (28) are relatively large, it stands to reason that the country risk premium is non-existent for both of the shorter horizons, i.e., 3M and 6M. Thus, the interesting case is 12M with a negative observed country risk premium that is significantly different from zero. This could imply that Sweden limits the efficiency of the capital market by using capital controls and transactions costs that in effect forces Swedish investors to invest, to a certain extent, more domestically, as opposed to what CIP naturally would suggest. The conclusion is that the capital market is near or perfectly mobile in the shorter horizons while significant country barriers exist in the yearly data which discourages Swedish capital outflow.
The slope coefficient $\beta$, on the other hand, is only rejected as unit for the 3M horizon with a value strictly less than one, which in turn limits the coefficient interpretation to this horizon only. This implies that a positive 3M interest rate differential yields a less positive forward premium in contrast to what CIP suggests. For instance, consider a 1% interest rate differential which theoretically should yield a 1% forward premium but as equation (27) shows, the forward premium is only 0.94%. This would as CIP suggests, lead to arbitrage opportunities as investors can make a profit surplus of 0.06% by investing in the domestic interest rate, STIBOR, knowing that the depreciation of SEK vis-à-vis Euro is not completely offsetting the higher domestic interest rate. Given the no arbitrage theorem, this cannot be true, especially for a 3-month horizon when investors have time to exploit arbitrage opportunities. It then stands to reason that the underlying assumption of assets being identical must fail. Thus, investors are likely to prefer EURIBOR to STIBOR as they consider the latter interest rate having more risk. That is, even if STIBOR yields a profit surplus, this surplus disappears as soon as investors adjust for the risks involved.

Another interesting feature of the CIP results is the statistically significant difference between the condition pre- and post-crisis. The pre-crisis slope coefficient $\beta$ is statistically significant larger than 1 for all three horizons. In the same line of reasoning as above, it suggests that investors perceived a higher risk in the EURIBOR relative to the STIBOR before the financial crisis. This behavior changed, though, as the estimated post-crisis slope coefficient is 0.58-0.76, meaning that STIBOR is now riskier than the EURIBOR, from an investor’s perspective. Similar market behavior changes are found with respect to the constant term $\alpha$ as it also proves statistically significant different between the two periods. The pre-crisis estimates are negative, interpreted as positive country risk premiums, indicating that capital inflow to Sweden were controlled by domestic barriers. After the financial crisis, not only is the capital inflow no longer restricted but capital outflow is discouraged as can be observed by the positive estimates of $\alpha$ equaling negative country risk premiums.

As a final remark on the CIP condition, it is clear the only horizon that strictly validates the relationship is the 6-month horizon when both $\alpha = 0$ and $\beta = 1$ cannot be rejected. 12M shows traits that potentially can validate CIP as $\beta = 1$ cannot be rejected, but nevertheless a small negative country risk premium is significant.
Continuing with the FRUH condition, the same procedure will follow. Recall that the foreign exchange risk premium is on the opposite side in equation (9) compared to that in the regression model (26), which means that it is necessary to change the sign of estimated foreign exchange risk premium for correct economic interpretations, i.e., \( P_{\text{Exchange}} = -\alpha \). Inserting estimated values for \( \alpha \) and \( \beta \) obtained from Table 13 and Table 14 in Appendix A, gives the specific values for 6M and 12M:

\[
\begin{align*}
6M: \quad S_{t+6M} &= 2.739473 + 0.699699 F^{6M}_t \\
&\quad (0.087107) \quad (0.009468) \\
12M: \quad S_{t+12M} &= 6.351007 + 0.306983 F^{12M}_t \\
&\quad (0.097561) \quad (0.010378)
\end{align*}
\]

The \( \alpha \) in both regressions are positive, indicating that the foreign exchange risk premium is negative. As explained earlier in section 2.2, a negative foreign exchange risk premium is interpreted as investors seeking risk. In both 6M and 12M the null hypothesis of the constant term and the slope coefficient are strongly rejected. Apparently, the estimated values are far from the expected values causing the FRUH to fail in these two longer horizons. The large negative foreign risk premiums indicates that investors are risk lovers, though it should be taken lightly as the results are not that reliable on these longer horizons as explained in section 5.4. Nevertheless, it is clear that FRUH does not hold for any of these two horizons.

Combined with the previous result on CIP, the nested formulation then implies that UIP cannot hold for any horizon. The failure of UIP over 6 months can be explained by the failure of FRUH where two main assumptions are challenged; rational expectations and risk neutrality among investors. Without further investigation, rational expectations cannot be the main reason for the failure of UIP. Apparently, risk neutrality is also relaxed as investors tend to seek more risk than justified by FRUH, indicated by the positive coefficients on \( \alpha \) in (30) and (31), and is probably a major reason of the failure as well. Hence, it is believed that one of the factors causing the failure of UIP in the 6-month horizon is due to the irregular risk attitude of investors, i.e., they are risk lovers instead of risk neutral. The same reasoning can be applied for 12M but for this horizon, it is even more negligible as CIP only holds in its weaker form.
6.2 Monetary Integration and a Potential Swedish EMU Entry

As described in the previous section, the joint hypothesis that both CIP and FRUH hold cannot be accepted for any time horizon, implying the failure of UIP for all horizons studied. In order to connect this result with discussion on monetary integration, it is essential to recall the risk averse version of UIP in (11). The condition states that given risk neutrality among investors, the interest rate differential should match the expected change in the spot exchange rate. As found out in section 6.1, the risk neutrality assumption is challenged and investors are more than willing to seek excess risk, i.e., $P_{\text{exchange}}^r < 0$ in (11). As a result, a 1% interest rate differential between Sweden and EMU would yield a higher than 1% expected change in the spot exchange rate, i.e., a larger depreciation in the SEK vis-à-vis the Euro than what UIP suggests. This implies, in monetary integration terms, that the SEK and the Euro cannot be considered as close currency substitutes as investors prefer holding Euro over SEK, ceteris paribus. This can potentially be explained by the difference in the risk perception of the two currencies. Moreover, economic theory suggests that small countries are usually more trade dependent. Sweden, a export oriented economy where the export share of GDP has been over 45% for the past decade (Statistics Sweden, 2014), is clearly more sensitive to exchange rate fluctuation due to its large impact on the economy in the whole. Because of this, the SEK is also more unstable than the Euro, which can be a factor why investors prefer Euro over SEK given the same return.

Holtemöller (2005) confirms the existence of a significant foreign exchange risk premium in the case of Sweden in his study of UIP as well as points out the lack of cointegrated interest rates between the countries. Both observations imply that there is low or no monetary integration between the countries and proves to disfavor a Swedish EMU entry. Nevertheless, to get a broader perspective on the topic it is important to address the question from other monetary integration aspects. One of them is correlation in monetary policies between countries and as literature suggests, this is commonly checked by performing cointegration tests on the corresponding interest rates (Reade & Volz, 2009). The empirical results are mixed and one reason for this is potentially that studies analyze different periods and because cointegration relationships often vary in time, results will too (Reade & Volz, 2009; Holtemöller, 2005). Even though this study has not focused on interest rate cointegration, unit root tests were still performed on the interest rate differential as a prerequisite for the remainder of the thesis. This result can thus be used as a point of discussion on the topic.
The results presented in section 5.1 show that the interest rate differential is integrated of order one over all time horizons; a contradiction to the cointegration of interbank rates in Sweden and the EMU, which rejects the notion of a potential entry. Reade and Volz (2009), on the other hand, found that Sweden and the EMU interbank rates are cointegrated and argued that there is no reason for Sweden to stay outside the monetary union as the monetary policies are highly dependent. More specifically, they found that the Swedish monetary policy imitated the corresponding policy conducted by the European Central Bank, where the former interest rate consistently lagged the latter. This subservient action by the Swedish Central Bank clearly eliminates the main advantage of staying out of the EMU; i.e., being able to conduct an autonomous monetary policy (Flam, 2011).

This difference in results from Reade and Volz (2009) is most likely due to the difference in periods studied (1987-2009 vs. 1999-2014) and the inclusion of the post-crisis period in this thesis, which was not included in their study. What might also have caused the discrepancy is that a surrogate for the EURIBOR using closely tied trading partners, e.g., Germany, is not produced in this thesis. Reade and Volz (2009) uses such a surrogate, which is more likely to be cointegrated with the STIBOR than the actual EURIBOR since the EMU needs to account for countries in the periphery of the union, where some have been highly unstable over the past decade. Moreover, dummy variables are extensively used by Reade and Volz (2009) in order to remove turbulent periods in their study as pointed out by Buscher and Gabrisch (2011). Instead, Buscher and Gabrisch (2011) mean that the Swedish interest rate is driven by the European interest rate only during tranquil periods, while the correlation disappears in turbulent times. This weakens the arguments provided by Reade and Volz (2009) and necessitates Sweden to conduct independent monetary policy in order to handle large deviations in the economic climate from the rest of the EMU in turbulent times.

Ultimately, it is also important to stress the differences in our objectives and methodologies. The conclusions drawn by Reade and Volz (2009) and Buscher and Gabrisch (2011) on a Swedish EMU entry rest upon assessments on monetary policy and not on currency substitutability which this thesis has mainly focused on. Both aspects are equally important in order to make a sound decision on a potential EMU entry but without further investigation in these areas, it is still uncertain whether a Swedish EMU entry is more beneficial than harmful. Thus, by only looking at the results from this thesis, a potential Swedish EMU entry is not motivated fully.
7 Conclusions

This thesis aimed to answer two related questions: 1) “Does the covered- and uncovered parity condition hold between Sweden and the EMU?” and 2) “Is there evidence of monetary integration between the two regions that could motivate a Swedish entry into the EMU?”. By performing unit root tests on the interest rate differential and the forward premium over time, the results point to a case where cointegration and CIP is only plausible for horizons 3M and above. Then, dynamic estimation of the hypothesized coefficients zero and one produced results in favor of CIP over the 6M and 12M horizons. This supports, after performing further tests on the FRUH, that UIP does not hold between Sweden and the EMU but CIP does. Thus, the ultimate answer for the former question is unequivocally that CIP holds for the 6M and 12M horizons and UIP does not for any.

In answering the latter question, further discussion on monetary policy drawing on past studies showed that the Swedish Central Bank mimicked the monetary policy decisions made by the European Central Bank. However, this was only found to be valid during tranquil periods as evidence indicated lack of interest rate co-movement during turbulent times. Consequently, with respect to this detail, there is no motivation for a Swedish entry into the EMU as the monetary policy is not completely integrated between the regions. Moreover, the rejection of UIP strengthens the motivation to stay out of the monetary union for capital market substitutability reasons. As such, Swedish and European markets are less integrated than one could imagine due to the presence of a significant foreign exchange rate risk premium between markets and the answer to the latter question, based on the results and discussion presented in this thesis, is therefore not in favor of a Swedish EMU entry.

The topic studied in this thesis is, of course, very debated and more studies on monetary integration would be needed to deduce potential EMU entry as it can be beneficial to Sweden in the long-run. For this purpose, it would be interesting to study the topic from different angles than that of interest rate parity. Potentially, it would suffice to study cointegration of interest rates in more detail than has done before, but also to conduct even more qualitative studies where the benefits are weighted against losses of a Swedish EMU entry. Furthermore, future studies could extrapolate on this thesis by studying real interest rate parity and the integration of physical assets instead of financial assets as this study has been focusing on, as well as extending the time horizons. Eventually, this would give policymakers and the private sector more insight into the relationship between Sweden and the EMU and how it affects their daily decision-making.
References


Appendix A: Tables

A.1 Forward Rate Unbiasedness Hypothesis Regressions

Table 8: FRUH Regression for 1D

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Null hypothesis</th>
<th>Coefficient</th>
<th>HAC standard error</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign exchange risk premium</td>
<td>$\alpha = 0$</td>
<td>0.011320</td>
<td>0.008696</td>
<td>1.301748</td>
<td>0.1931</td>
</tr>
<tr>
<td></td>
<td>$\beta = 1$</td>
<td>0.998796</td>
<td>0.006964</td>
<td>-1.24963</td>
<td>0.2118</td>
</tr>
</tbody>
</table>

Summary statistics:
- Numbers of:
  - R-squared: 0.998958
  - Observations: 3407
  - Leads: 2
  - Lags: 29

Table 9: FRUH Regression for 1W

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Null hypothesis</th>
<th>Coefficient</th>
<th>HAC standard error</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign exchange risk premium</td>
<td>$\alpha = 0$</td>
<td>0.004261</td>
<td>0.008707</td>
<td>0.489376</td>
<td>0.6246</td>
</tr>
<tr>
<td></td>
<td>$\beta = 1$</td>
<td>0.999489</td>
<td>0.000965</td>
<td>-0.529534</td>
<td>0.5965</td>
</tr>
</tbody>
</table>

Summary statistics:
- Numbers of:
  - R-squared: 0.998958
  - Observations: 3404
  - Leads: 6
  - Lags: 28

Table 10: FRUH Regression for 1M

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Null hypothesis</th>
<th>Coefficient</th>
<th>HAC standard error</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign exchange risk premium</td>
<td>$\alpha = 0$</td>
<td>-0.016816</td>
<td>0.008336</td>
<td>-2.01727</td>
<td>0.0437</td>
</tr>
<tr>
<td></td>
<td>$\beta = 1$</td>
<td>1.001563</td>
<td>0.009222</td>
<td>1.695228</td>
<td>0.0901</td>
</tr>
</tbody>
</table>

Summary statistics:
- Numbers of:
  - R-squared: 0.998904
  - Observations: 3386
  - Leads: 23
  - Lags: 29

Table 11: FRUH Regression for 2M

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Null hypothesis</th>
<th>Coefficient</th>
<th>HAC standard error</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign exchange risk premium</td>
<td>$\alpha = 0$</td>
<td>0.432624</td>
<td>0.062543</td>
<td>6.917225</td>
<td>4.88E-12</td>
</tr>
<tr>
<td></td>
<td>$\beta = 1$</td>
<td>0.952176</td>
<td>0.00914</td>
<td>-6.91698</td>
<td>4.94E-12</td>
</tr>
</tbody>
</table>

Summary statistics:
- Numbers of:
  - R-squared: 0.889200
  - Observations: 3371
  - Leads: 28
  - Lags: 23

Table 12: FRUH Regression for 3M

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Null hypothesis</th>
<th>Coefficient</th>
<th>HAC standard error</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign exchange risk premium</td>
<td>$\alpha = 0$</td>
<td>1.096611</td>
<td>0.088365</td>
<td>12.41062</td>
<td>1.28E-34</td>
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<tr>
<td></td>
<td>$\beta = 1$</td>
<td>0.879378</td>
<td>0.009756</td>
<td>-12.36388</td>
<td>2.22E-34</td>
</tr>
</tbody>
</table>

Summary statistics:
- Numbers of:
  - R-squared: 0.761601
  - Observations: 3372
  - Leads: 28
  - Lags: 0
Table 13: FRUH Regression for 6M

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Null hypothesis</th>
<th>Coefficient</th>
<th>HAC standard error</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign exchange risk premium</td>
<td>$a = 0$</td>
<td>2.73973</td>
<td>0.087107</td>
<td>31.44951</td>
<td>8.32E-191</td>
</tr>
<tr>
<td>F6M</td>
<td>$\beta = 1$</td>
<td>0.699669</td>
<td>0.009468</td>
<td>-31.72064</td>
<td>1.10E-193</td>
</tr>
</tbody>
</table>

Summary statistics:
- R-squared: 0.483329
- Observations: 3306
- Leads: 28
- Lags: 0

Table 14: FRUH Regression for 12M

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Null hypothesis</th>
<th>Coefficient</th>
<th>HAC standard error</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign exchange risk premium</td>
<td>$a = 0$</td>
<td>6.351007</td>
<td>0.097561</td>
<td>65.0978</td>
<td>0.00E+00</td>
</tr>
<tr>
<td>F12M</td>
<td>$\beta = 1$</td>
<td>0.306983</td>
<td>0.010378</td>
<td>-66.77751</td>
<td>0.00E+00</td>
</tr>
</tbody>
</table>

Summary statistics:
- R-squared: 0.119882
- Observations: 3174
- Leads: 28
- Lags: 0

A.2 Covered Interest Parity Regressions Pre-crisis

Table 15: CIP Regression Pre-crisis for 3M

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Null hypothesis</th>
<th>Coefficient</th>
<th>HAC standard error</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country risk premium</td>
<td>$a = 0$</td>
<td>-0.000278</td>
<td>-0.000040</td>
<td>-6.881188</td>
<td>7.85E-12</td>
</tr>
<tr>
<td>STIBOR3M-EURIBOR3M</td>
<td>$\beta = 1$</td>
<td>1.179796</td>
<td>0.033248</td>
<td>5.407724</td>
<td>7.12E-08</td>
</tr>
</tbody>
</table>

Summary statistics:
- R-squared: 0.446500
- Observations: 2064
- Leads: 0
- Lags: 22

Table 16: CIP Regression Pre-crisis for 6M

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Null hypothesis</th>
<th>Coefficient</th>
<th>HAC standard error</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country risk premium</td>
<td>$a = 0$</td>
<td>-0.000525</td>
<td>0.000081</td>
<td>-10.9603</td>
<td>3.29E-27</td>
</tr>
<tr>
<td>STIBOR6M-EURIBOR6M</td>
<td>$\beta = 1$</td>
<td>1.124775</td>
<td>0.018580</td>
<td>6.715554</td>
<td>2.41E-11</td>
</tr>
</tbody>
</table>

Summary statistics:
- R-squared: 0.677992
- Observations: 2063
- Leads: 0
- Lags: 23

Table 17: CIP Regression Pre-crisis for 12M

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Null hypothesis</th>
<th>Coefficient</th>
<th>HAC standard error</th>
<th>t-statistic</th>
<th>p-value</th>
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<tr>
<td>Country risk premium</td>
<td>$a = 0$</td>
<td>-0.000940</td>
<td>0.000081</td>
<td>-11.6049</td>
<td>3.3E-30</td>
</tr>
<tr>
<td>STIBOR12M-EURIBOR12M</td>
<td>$\beta = 1$</td>
<td>1.070627</td>
<td>0.014069</td>
<td>5.020044</td>
<td>5.61E-07</td>
</tr>
</tbody>
</table>

Summary statistics:
- R-squared: 0.762771
- Observations: 2036
- Leads: 25
- Lags: 25
### A.3 Covered Interest Parity Regressions Post-crisis

#### Table 18: CIP Regression Post-crisis for 3M

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Null hypothesis</th>
<th>Coefficient</th>
<th>HAC standard error</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country risk premium</td>
<td>$a = 0$</td>
<td>0.000978</td>
<td>0.000142</td>
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<td>STIBOR3M EURIBOR3M</td>
<td>$\beta = 1$</td>
<td>0.584335</td>
<td>0.054582</td>
<td>-7.615093</td>
<td>4.98E-14</td>
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</table>

**Summary statistics**

<table>
<thead>
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<td>Adjusted R-squared</td>
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<td>Standard error of regression</td>
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#### Table 19: CIP Regression Post-crisis for 6M

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<th>HAC standard error</th>
<th>t-statistic</th>
<th>p-value</th>
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<td>$a = 0$</td>
<td>0.001619</td>
<td>0.000147</td>
<td>11.01361</td>
<td>4.69E-27</td>
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<td>$\beta = 1$</td>
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**Summary statistics**

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#### Table 20: CIP Regression Post-crisis for 12M

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<th>HAC standard error</th>
<th>t-statistic</th>
<th>p-value</th>
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<tbody>
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<td>0.000202</td>
<td>19.35149</td>
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<td>STIBOR12M EURIBOR12M</td>
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**Summary statistics**

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<td>Adjusted R-squared</td>
<td>0.547948</td>
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<td>Standard error of regression</td>
<td>0.005139</td>
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Appendix B: Figures

B.1 Interest Rate Differentials and Forward Premiums

Figure 5: Interest Rate Differential and Forward Premium for 1D

![Graph showing the interest rate differential and forward premium for 1D.]

Figure 6: Interest Rate Differential and Forward Premium for 1W

![Graph showing the interest rate differential and forward premium for 1W.]

Figure 7: Interest Rate Differential and Forward Premium for 1M

![Graph showing the interest rate differential and forward premium for 1M.]

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Figure 8: Interest Rate Differential and Forward Premium for 2M

Figure 9: Interest Rate Differential and Forward Premium for 3M

Figure 10: Interest Rate Differential and Forward Premium for 6M
B.2 Covered Interest Parity Regression Residuals

Figure 11: Interest Rate Differential and Forward Premium for 12M

Figure 12: CIP Regression Residual for 1D

Figure 13: CIP Regression Residual for 1W
B.3 Forward Rate Unbiasedness Hypothesis Regression Residuals
Figure 20: FRUH Regression Residual for 1W

Figure 21: FRUH Regression Residual for 1M

Figure 22: FRUH Regression Residual for 2M
Figure 23: FRUH Regression Residual for 3M

Figure 24: FRUH Regression Residual for 6M

Figure 25: FRUH Regression Residual for 12M